SUD-EST AVIATION has opened a sales offi ce at 500 Fifth Avenue, New York 36, N.Y. Engineer G C. Teyssier, former Director of Air Navigation at the Secretariat General for Civil and Commercial Avi and Engineer Darrieus are in charge of the new office, which will be responsible for the company's sales ties in the United States, Canada and Mexico.

FIAT has received a sub-contract from Sud-Est Aviation, under an agreement concluded in June 1953 pr for collaboration in the field of helicopter production, for license manufacture of parts for Sikorsky S-58 copters ordered by the French Government.

LEAR S.A., Geneva, has begun production of Lear automatic pilots. So far, 80 per cent of the orders r have been passed on to sub-contractors. The company's order backlog at present totals $1,000,000. Th va plant employs more than 100 persons, a figure which will probably be doubled during the first half of and may eventually reach 2,000.

MARTIN INTERNATIONAL is a new wholly owned subsidiary of The Martin Company which will explore develop world markets for nuclear powered electrical generating systems. George B. Shaw, at present M Vice President-Procurement and former Director of Commercial Sales, has been named President of the n pany.

THE LAST OF 888 BOEING C-97 STRATOFREIGHTERS was delivered to the U.S. Air Force at Renton, W ton, recently and was flown to Lincoln Air Force Base, Nebraska, where it joined the 98th Air Refueling dron of the Strategic Air Command. The delivery marked the end of a 12-year Stratofreighter programme ing Airplane Co.'s Renton plant.

CEYLON HAS OFFERED THE WEST GERMAN AIRLINE LUFTHANSA the use of Ceylon airports in return traffic rights on commercial airports in Germany. Transport Minister Maithripala Senanayake also has in Italian Government representative to visit Ceylon early next year to discuss reciprocal air traffic rights.

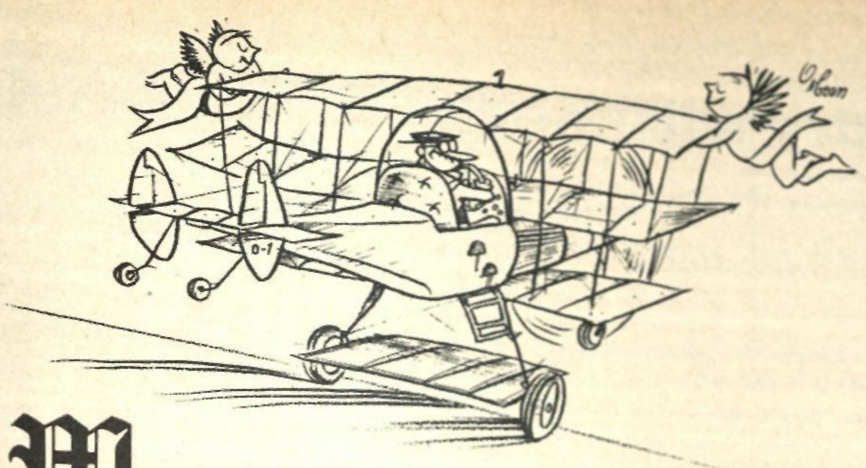
THE GENERAL MEETING OF LUFTHANSA STOCKHOLDERS on December 4th will be asked to authoriz sue of new shares which would raise the company's basic capital of 80,000,000 DM by a maximum of 40, 000 DM. The shares would be offered to existing stockholders only.

*

WORKSHOP BRIEFS . . .

The U.S. Civil Aeronautics Administration is to test three new runway lighting systems during the coming in a search for methods of overcoming deficiencies in the systems at present in use. By March 1957 C.A. plans to have worked out exact regulations for improvements in runway lighting to ensure that both civil tary requirements are met. It is also planned to submit these regulations to I.C.A.O. for possible accep as international standards. * Two prototypes of a new three-engined "flying platform" (with 44 h.p. two engines) have been ordered from Hiller Helicopters for the U.S. Army. * A new version of the Grumman designated F11F-1F, is being tested. Unlike earlier versions which have a J-65 jet with afterburner, the 1F is powered by a General Electric J-79 jet with afterburner. * The Bristol Centaurus 373 piston engine direct fuel injection (take-off power 3,150 h.p.), which was developed for possible installation in the Bl burn and General Aircraft Beverley transport, is now to be tested in flight. * The Scottish Aviation Twin neer short range feeder aircraft has been granted a type certificate. * A pre-production batch of Temco 1 target aircraft with rocket power has been ordered by the U.S. Navy. It is reportedly capable of top s in the neighbourhood of Mach 1 and altitudes of up to 50,000 ft. * An American Doman helicopter (prob YH-31) has made a series of demonstration flights to representatives of the Brétigny Flight Test Centre, at request of Générale Aeronautique Marcel Dassault. It is rumoured that Dassault plans to build this helic under license in France. * The helicopter division of Sud-Est Aviation has completed work on the SE.31 sion of the Alouette turbine-powered helicopter. The new version has a longer and wider cabin for seven sons; power plant 1 Turbomeca Artouste. * Sikorsky has converted an HR2S-1 Navy helicopter (Army de tion H-37A) to take early warning radar equipment, under contract to the U.S. Navy. The latter plans t this helicopter to determine whether the early warning range of ships' radar can be increased by using hel ters as radar carriers. * A U.S. Air Force Boeing B-52 Stratofortress eight-jet long-range bomber lande timore international airport on November 25th after being in the air - with several in-flight refuellings - 31 1/2 hours and having covered a distance of roughly 16,000 miles. It had taken off from Castle AFB, C fornia, on November 24th and flown over Thule (Greenland), the North Pole, Anchorage (Alaska) and Sa Francisco. * First Boeing-produced KC-135 tanker will be delivered to the Strategic Air Command's B-5 at Castle AFB, Calif., in late spring 1957. The 93rd Bomb Wing is now organizing a training cadre for a out of training crews. Castle AFB will be the centre of the training personnel for all SAC units. * The M III has made its first flight at Melun-Villaroche, piloted by Dassault Assistant Chief Test Pilot Glavany. aircraft, fitted with a SNECMA ATAR G with reheat, is the first French "coke bottle" machine to fly.

* * *



May a squadron of Guardian Angels escort you through 1957

* * *

INTERAVIA
Editors and Publishers

Sun, Moon and Stars

The title has a seasonal sound. It probably sounded tempting to the Editors, for it was decided several months ago that this year's Christmas issue should be devoted to a topical, but peaceful subject, namely space travel. And as the outlook on our own planet was far from rosy in November 1956, it seemed doubly indicated to look around for happier stars.

There were also, however, more concrete reasons for choosing this subject. We are approaching the beginning of the *International Geophysical Year**, which will see the first practical beginnings of space travel in the form of the launching of the first artificial earth satellites. In the autumn of 1956 we attended two congresses in Italy at which well-known scientists and technically qualified officers from throughout the world expounded their views on space vehicles and rockets. The impression was that research has taken a major step forward and moved closer to practice.

*

Nevertheless, we realize that some of our readers may well shake their heads over the contents of one article or another, just as we have done. We can imagine that airline heads, for example, will not altogether follow the thinking of certain highly esteemed scientists when they proclaim in all seriousness that man will one day travel the length of the Milky Way at the speed of light (300,000 kilometres per second)... We have as far as possible sifted the practical from the purely fantastic and gathered together a presentable list of authors for this space travel issue. Unfortunately our old friend Dr. Theodore von Karman was unable to write for us because of illness, but we are glad to say he is now well on the road to recovery.

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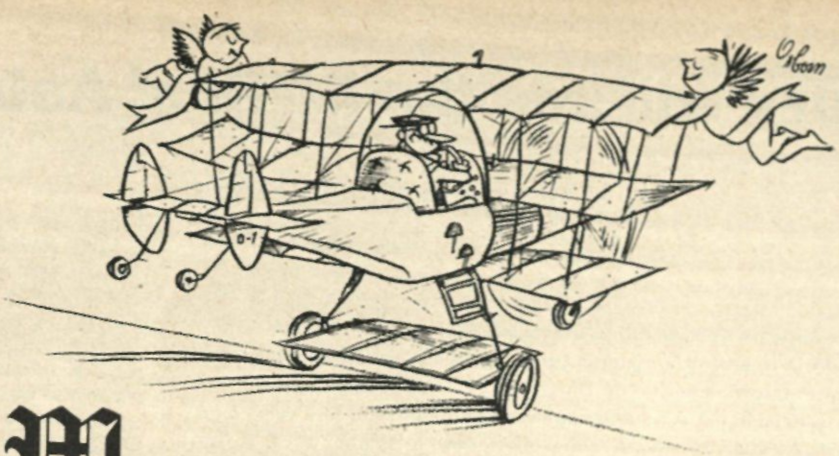
* The object of the research programme for the International Geophysical Year is to improve our meteorological knowledge through simultaneous world-wide observation of all weather factors both from the ground and in the upper atmosphere, including radiation measurements. The I.G.Y. begins on July 1st, 1957, and ends on December 31st, 1958.

The attentive reader will hardly emerge with the feeling that the subject of space travel is above his head (in a figurative sense, of course). The possibility of official experiments with space rockets was alluded to already at the end of World War II by the late General of the Army Henry H. Arnold, former Commanding General of the U.S. Army Air Forces, in the conclusions to his final report on the war activities of the U.S.A.A.F., published on November 11th, 1945. And in a memorandum of December 29th, 1948, the late U.S. Secretary of Defense James V. Forrestal stated: "...... The Earth Satellite Vehicle Programme, which is being carried out independently by each military service, has been assigned to the Committee on Guided Missiles for coordination." It may now be re-called that in April 1949 *Interavia,* in an article entitled: "Castles in and beyond the Air", pointed out: "... Sooner or later the artificial satellites will rotate around the earth, even not without the dimensions and luxury attributed to them by over-enthusiastic journalists ..." What at that time sounded like a dream or Utopia is now about to be realized. Today the picture is a different. Nevertheless, many of the space enthusiasts' dreams will probably remain unfulfilled for many years to come, perhaps for ever, even if their sponsors do firmly believe in them and presented them to the Rome Congress as if they were established facts.

Writing 150 years ago, Johann Wolfgang von Goethe described this mental attitude in a single sentence. When Heinrich Faust, Ph.D., LL.D., M.D. demanded that Mephistopheles should procure fresh jewels for Gretchen—the first set had been "swept away" by a "rascal priest"—Mephistopheles set about his task with reluctance: "*Such lovesick fools away would puff sun, moon and stars into the air, and all to please their lady fair.*"

Many space travellers, like Faust, would sacrifice all the heavenly bodies on the altar of their own pet projects.

EEH



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Our Century will see the Birth of Astronautics

by Professor Gaetano Arturo Crocco, Rome

Born in 1877, the author joined the «Brigata Specialisti» of the Italian Engineers Corp at the turn of the century, holding a leading position in it until 1923. He spent the next few years at the Ministry of Economics as industry representative, was appointed to the University of Rome (chair of aviation) in 1927 and reactivated as a Lieutenant General in the Air Force Engineers Corps in 1928. Five years later he became research chief at the Italian Air Ministry. — G. A. Crocco has been a member of the Accademia dei Lincei since 1919, of the Accademia d'Italia since 1932 and of the Papal Academy since 1936, as well as a corresponding member of aeronautical institutions throughout the world. Finally he is President of the Associazione Italiana Razzi (Italian Rocket Association) in Rome. — Editors.

The roads on land were travelled at increasing speeds once the wheel was invented and supplied with motive power.

The sea lanes were travelled faster and faster once the floating body was invented and supplied with motive power.

The air routes were travelled once the supporting wing was invented and supplied with motive power.

Man's three means of locomotion—land, sea and air—are thus all attributable to the solution of two technical problems, support and propulsion; support to bear the weight of the vehicle; propulsion to overcome the resistance to motion raised by speed and by the support itself.

In all three cases, movement takes place in three essential phases. In the first phase the vehicle accelerates to a given speed; in the second it maintains this speed by opposing a continuous propulsive force to the resistance provided by its motion; in the third phase the vehicle brakes its speed and comes to a standstill.

*

Today, with astronautics, men's minds are seeking to create a fourth type of locomotion—space travel—that will escape from land, sea and atmosphere and navigate in a vacuum. But it should be stressed immediately that an absolute vacuum does not and cannot exist, except in certain privileged regions of the universe. Apart from these regions, in the rest of the universe there is always a residue of interstellar matter of approximately one atom of hydrogen per cubic centimetre.

The resulting density of matter is extremely low, and a spaceship moving among it at astronomical speed, i. e., at the speed of the stars or the planets, can travel for millions of centuries without needing propulsion. Only when a spaceship can move in interstellar space at a superastronomic speed approaching that of light, will it be necessary to overcome the resistance of interstellar matter by means of a propulsive force.

In the case of the interplanetary travel so far envisaged in astronautical engineering, travel that will take place at speeds much lower than that of light, the problem of propulsive force during movement does not arise, since there is no passive resistance. Nor is there any problem of support. As the vehicle is subject only to Newtonian forces of gravitation it will automatically develop at all points of its orbit a centrifugal force equal and opposite to its weight.

But then, what technical problems remain to be solved in space travel when the two typical problems of other types of locomotion, propulsion and support, no longer arise? There remain only the problems of acceleration and stopping, i. e., the first and the third phases. The first phase becomes essentially a problem of launching, the third a problem of braking.

The intermediate phase covering most of the trajectory takes place by inertia, with rockets extinguished, and can thus be called the inertial phase.

The space vehicle must therefore be launched from the ground as, in ballistics, a shell is fired from a gun; i. e., it must be subjected to a purely temporary propulsive thrust which, after overcoming atmospheric resistance and terrestrial gravity, ceases when the vehicle's speed is high enough for the planned space mission.

This notion of temporary propulsive force is the reason for my choosing the expression *ballistic locomotion* and the word *missile* (meaning "object thrown" in Latin) for the vehicle. But the launching of the missile does not need a gun. The propulsive charge is contained within the vehicle from the moment of launching and operates even in an absolute vacuum, as it acts only against itself. *The spaceship must therefore be fitted with a rocket motor.*

*

In essentials, a rocket motor is a power unit consisting of a combustion chamber in which an explosive mixture is burned at a predetermined rate and from which a powerful jet of burnt gases then exhausts. The higher the speed of the jet, the higher the speed it imparts to the vehicle. All progress in rocket engineering lies in increasing the speed of the jet and in controlling its regularity.

Great strides have been made in both these directions. Today the rocket is sufficiently advanced to leave our earth altogether, to open the new era of space travel. This era will have a beginning and an end.

The first step will be the construction of the first circumterrestrial missile, or artificial satellite; the last step that of a manned vehicle to travel through interstellar space.

Between these two extreme points falls the whole technique of rockets and spaceships, the whole science of circumterrestrial and extraterrestrial travel, the whole research into ultimate objects and means of achieving them. The satellite can be achieved shortly, interstellar travel is a much more distant prospect.

The coming International Geophysical Year will see the first step into the future in the form of unmanned instrument stations launched around the earth without human control. Probably America will not be alone in this new international undertaking.

Further steps—in a sense intermediate stages in space travel—will be interplanetary journeys inside our solar system. At the recent 7th International Astronautical Congress in Rome I endeavoured to demonstrate that a round trip from earth to Mars and Venus and back to earth within a year is technically feasible and that a favourable constellation for such a trip will exist in 1971.

*

The Church and Astronautics

Extracts from the address by His Holiness Pope Pius XII at Castel Gandolfo to the delegates to the 7th I.A.F. Congress

On the occasion of the 7th Congress of the International Astronautical Federation which has brought you to Rome this year, you have expressed the desire to associate Us in a sense with your work. We are happy that this should be so and would express Our admiration for the conviction, tenacity and courage of all those who have been advancing step by step during the past fifty years towards the conquest of this vast domain.

On first hearing of your activities and of your Federation's aims, the layman cannot avoid a feeling of astonishment; the very word "astronautics" suggests the idea of fantastic voyages through vertiginous spaces and under conditions of especial danger to the human organism thus projected outside its natural element. There are still many people who feel that a project for such an expedition can originate only in an unbridled imagination with little respect for solid data. Yet even at the beginning of the century the fundamental principles on which astronautics was to be based had already been clearly and logically formulated. It was asserted that a moving object could escape from terrestrial gravity if it had sufficient acceleration, and that this acceleration could be obtained by using a rocket; soon the possibility of manned space travel was also envisaged...

...Today you do not hesitate to tackle the more general problems set by the conquest of interplanetary space; and it even appears from the documents you have communicated to Us that some of you have gone as far as examining the abstract possibility of interstellar travel, which the very name of Astronautics indicates to be the ultimate aim of your work.

Without going into details, it will not have escaped you that a project of such scope involves intellectual and moral aspects which cannot be ignored; it postulates a certain concept of the world, of its meaning and its finality. The Lord God, who implanted in man's heart an insatiable desire for knowledge, did not place any limit on his efforts at conquest when He said: "Subdue the earth" (Gen. 1, 28). It was rather the whole of creation which He offered for the human spirit to penetrate and thus understand more and more profoundly the infinite greatness of the Creator. If hitherto man has felt, so to speak, shut up on the earth and has had to be content with the fragments of information which reached him from the universe, it now looks as if the prospect is opening up to him of breaking these barriers and advancing towards new truths and new knowledge which God has placed in the world in profusion. With mere curiosity or adventurousness as a motive it will never be possible to orientate correctly efforts of such a scope. Faced with the new situations created by the intellectual development of mankind, conscience must take a stand; man should broaden his knowledge of himself and of God, so as to find his true place in the world as a whole and to recognize more exactly the implications of his actions. This common effort by the whole of mankind towards the peaceful conquest of the universe should help to impress more firmly on men's consciences a sense of community and solidarity, so that all should feel more strongly that they are members of God's great family and children of the same Father. To penetrate this truth requires just as much respect for the true, acceptance of the real, and courage as does scientific research. The most daring explorations of space will merely introduce a new ferment of dissension among men unless they are accompanied by deeper moral reflection and a more conscious attitude of devotion to the higher interests of mankind.

We hope sincerely that the present Congress will advance you on your long and difficult road and would wish above all that the scope of the spiritual discoveries made will be in no way inferior to the scientific progress.

In asking for you the protection and favours of God, who made the universe for man so that he might know and love Him, We bestow on you, your families and your associates, in His name, Our Apostolic Benediction.

His Holiness Pope Pius XII receives the astronauts in audience. To the right of the Pope, Professors von Kármán (with black tie) and G. A. Crocco (with chain), left General Bergeron (profile) and F. C. Durant (behind).

And what of interstellar travel, the astronaut's ultimate goal?

Before we can discuss this subject seriously we must basically change our thinking, from Newton's to Einstein's laws of mechanics.

If a spaceship succeeded in penetrating non-gravitational space and—despite the resistance of interstellar matter—in moving in it at speeds approaching that of light, then even other solar systems would in principle be accessible to us.

At the same time, however, all lengths on board the spaceship would shrink, time (as measured by the occupants' pulses or the oscillations of the chronometer's balance) would dilate, masses would grow. For example it can be imagined that, at a certain speed of the spaceship, one day on board would be equal to 365 days, or a whole year, on earth. Thus, on returning to earth, our astronauts could meet the tenth or twentieth generation of their own descendants.

Whether such speeds can ever be achieved, or whether they will be prevented by the resistance of interstellar matter or the radio-active heating of the spaceship and its crew, is another question. In theory, at any rate, we are justified in thinking of these speeds.

*

Are we justified, however, in taking the last logical step and assuming a spaceship speed exactly equal to the speed of light? I do not think we are. For that would take us outside the realm of physics into the realm of metaphysics. Man cannot, by travelling at the speed of light, make himself immortal in this life; only his non-material soul is immortal.

What is light after all?

Light was created on the first day of Genesis and was the most miraculous expression of creation since it gave the universe a measure of time and distance. God himself saw that it was good.

Later—says Genesis—God created man in His image and likeness and gave him a sign of His divinity.

Now I like to imagine that this sign of divine being was a ray of light. Then the human spirit would be neither more nor less than a ray of light incorporated in the living matter. Its personality is determined by the wave length. And there is an infinite number of wave lengths.

Finally I like to think that on leaving its material hull the human spirit resumes its astral and divine nature and is destined to travel through the universe at the speed of light, a perennial symbol of immortality and eternity.

Space travel

The 7th International Astronautical Congress in Rome

Congress hall (at the Esposizione Universale di Roma) and Contin MR. 27 rocket.

The ineradicable impression made on any unbiassed observer listening to the 44 brief lectures or examining the nearly 5 lbs. of printed matter issued by the 7th International Astronautical Congress was that of a dream world. — A rocket with a launching weight of 10, or perhaps 100, tons? That could at best be of interest to the military, but certainly not to a space traveller. Much better take several hundred three-stage rockets of 10,000 tons each and build a "city in space" somewhere about the year 1971. — How nice it would be to present not only the earth but also the moon with artificial satellites, which could be observed through a twelve-inch telescope! All that is needed for this is a single multi-stage rocket weighing roughly 450 tons and a control system twenty times as accurate as the one planned for the *Vanguard* earth satellite. — Bravo, Colonel F. K. Everest, who flew the Bell X-2 rocket aircraft (since crashed) in July this year at a speed of 2,500 m.p.h., or slightly more than one kilometre a second. Does not this justify us in thinking already of a speed some 300,000 times higher, at which we can some day travel through the whole Milky Way? . . .

For the first time in the history of astronautics a space travel project is about to be put into practice: model of the 20-inch spherical satellite for *Project Vanguard* at the Hayden Planetarium, New York.

It should, however, be added that not all the lecturers allowed their thoughts to fly through interplanetary or interstellar channels. A good half of them kept at least one foot firmly on this earth and described either interesting details of rocket engineering and concrete medical research work, or discussed the United States earth satellite programme for the International Geophysical Year. *Not only sun, moon and all the stars, but also our own planet came in for its share of attention.*

1. Earth satellites

For the first time an international astronautical congress had the advantage of being able to point to a space travel programme that is not only practical but even about to be put into operation. As *F. C. Durant*, outgoing President of the International Astronautical Federation, put it, we are now in "the year minus one or minus two of the space travel era." Only a world disaster could prevent the United States from launching a whole series of dwarf satellites, with the aid of *Vanguard* three-stage rockets, from the southern tip of Florida during the I.G.Y. and setting them to circle the earth on an elliptical orbit.

Special interest was shown by the Congress delegates in the paper read by *N. E. Felt Jr.* (The Glenn L. Martin Company), who reported on the structure and dimensions of the *Vanguard* satellite vehicle (see box on page 958). For many space travel enthusiasts, however, the lecture will have been a disappointment in that it revealed that a total launching weight of no less than 22,600 lbs. is required in order to accelerate a miniature satellite of only 21.5 lbs. to orbiting speed. This gives a payload ratio of 1 : 1,050, whereas hitherto it has been assumed that very much more favourable figures, such as 1 : 500 or 1 : 200, could be obtained.

Details of the satellite movements were discussed by *J. DeNike* (Glenn L. Martin) and *Dr. W. B. Klemperer* (Douglas Aircraft Company), both engineers. While DeNike spoke on the effect of the earth's oblateness and of the earth's atmosphere on the movements of the artificial moon, Dr. Klemperer showed that a satellite that was not a perfect sphere, for example an ellipsoid such as our natural moon, would carry out pendulum-like oscillations (librations), which can be calculated. Other excellent papers on satellite orbit calculations were read by *Dr. Ing. J. Kooy* (Royal Netherlands Military Academy) and *Dr. H. Krause* (Institute for the Physics of Jet Propulsion, Stuttgart). *Professor S. F. Singer* (one of the authors in the present issue) announced methods of estimating the temperature of earth satellites, *Professor L. Whipple* (Smithsonian Institution) spoke on preparations for optical and radio tracking of the I.G.Y. satellites, and *Dr. Ing. F. Romano* (Contraves Italiana) expatiated on the possibility of protecting manned satellites, which in his view might some day be used as weapons, from radio or visual detection.

On the other hand, *D. Romick* (Goodyear Aircraft Corp.) entered the realm of "technically based speculation" with the concept of a large manned—not to say populated—satellite, the *Meteor* (abbreviation for "Manned Earth-satellite Terminal evolving from Earth-to-Orbit Rockets"), which he backed up with structural and operational details in the form of drawings and diagrams, and a time schedule. Though the lecturer stressed that he was not putting forward any final project but merely proposing a basic concept which could be reduced in size to any extent desired (down to one tenth of the original), his ideas still appear entirely fantastic even when so reduced. Romick's original project calls for three-stage feeder rockets each with three delta wings and a launching weight of 9,000 plus 1,250 plus 140 short tons for a 35-ton payload, construction of a drum-shaped "city in space" 2,500 ft. long and 1,000 ft. in diameter, to be put together from the final stages of the rockets and parts of their payload; orbit altitude 500 miles; development to begin in 1959, construction in 1964 (feeders) and 1968 (satellite); beginning of operation, 1971.

2. Sun

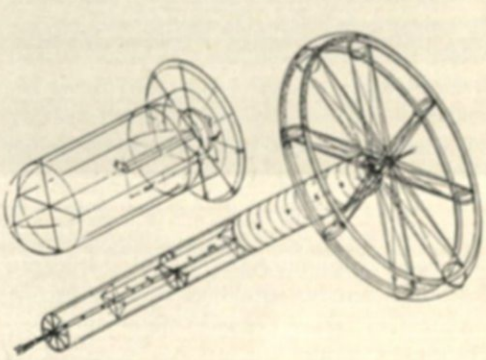
The sun, its radiation and its planetary system was the subject of a number of papers, the three most interesting of which are discussed below.

Dr. med. H. Strughold (School of Aviation Medicine, Randolph AFB), in a paper read for him by his colleague Dr. S. J. Gerathewohl, examined the so-called ecosphere of our planetary system, that is, the zone surrounding the sun in which any form of plant or animal life is possible. The former requires biologically supportable temperatures and the presence of liquid water, the latter a percentage of oxygen in the atmosphere as well. Dr. Strughold's conclusions are distinctly sobering for would-be planetary colonizers: "Beyond Venus—on Mercury—it is too hot; beyond Mars—from Jupiter to Pluto—it is too cold… Mars is a very dry planet with perhaps sufficient moisture to support lower forms of life. In the Venusian atmosphere water has not yet been detected. The atmosphere round Mars contains oxygen compounds such as carbon dioxide, but no free oxygen; the same applies to Venus. The zone not entirely inimical to life stretches at most over 5 percent of the distance between the sun and Pluto, and our earth lies in its "golden mean." Some of the space travel stalwarts might, however, find a certain comfort in the assumption that among the (estimated) 100 trillion other suns and stars in the whole universe there are perhaps 100,000 "bioplanets" capable of supporting life and hence—in principle at least—suitable for colonization. "Yet all of this", said Dr. Strughold, "is, and probably must forever remain, a matter of delightful speculation."

The sun's radiation and its use as a source of energy for space travel purposes were discussed by *Dipl. Ing. K. A. Ehricke* (Convair Division, General Dynamics). The sun's energy would be of particular value as a source of power for spaceships travelling at low thrust far outside the earth (and starting from satellite orbits), but could also be used to power satellite stations. In order to collect the sun's energy, Ehricke proposes the use of large plastic balloons with transparent envelopes roughly 0.001 inch thick, one half of whose inner surface would form a hollow mirror. The sunlight reflected on the centrally placed heating element would heat up hydrogen, which would then be ejected through rocket nozzles.

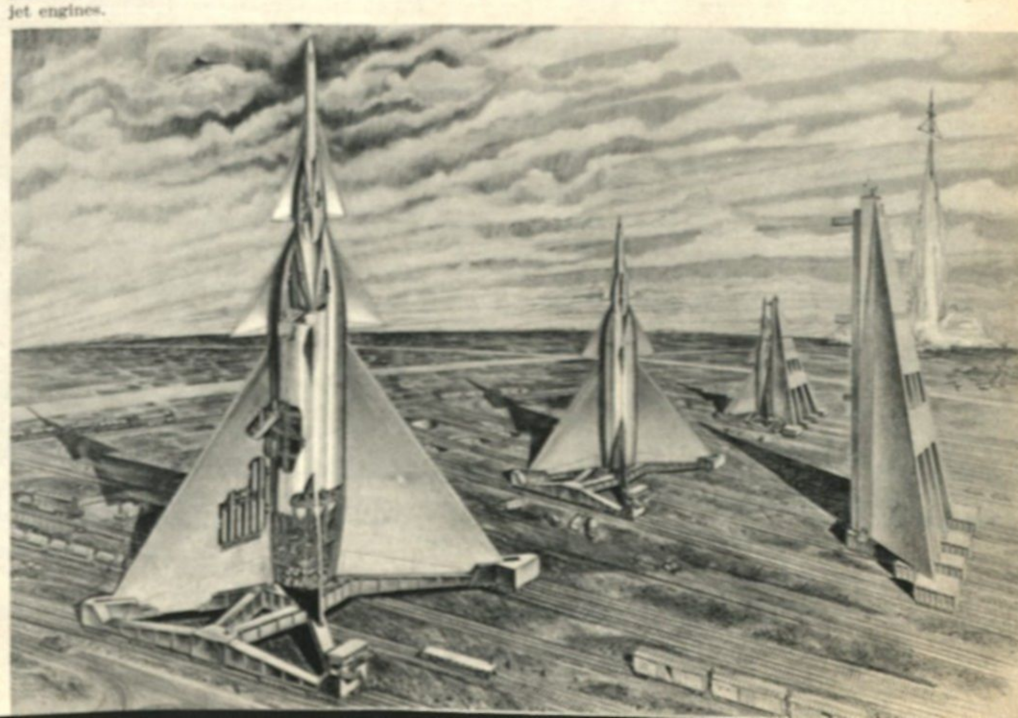
Finally mention should be made of the paper by *Professor G. A. Crocco* (University of Rome, and many scientific academies), who was the only lecturer to speak of the possibility of interplanetary travel, namely, to the two nearest planets, Mars and Venus. Crocco suggests that this journey should begin in June 1971, when there will be a favourable constellation for its completion within a year: the "hop" to Mars would then take 113 days, Mars to Venus 154 days, and Venus back to earth 98 days.

This is how the Akron engineers imagine the foundation stone for the "city in space" will be laid: the first two final stages of ferry rockets are placed nose to nose and joined with rings and stringers. A third ferry (foreground) is apparently awaiting its turn (drawing by Russell Lehmann).



For operation in 1971! Drawing of the *Meteor* super-satellite projected by Goodyear engineers of Akron, Ohio, and consisting of a stator 2,500 ft. long (diameter 1,000 ft.) and a rotating "residential wheel" 1,500 ft. in diameter. *Right*, building the inner stator tubes and the hub for the "residential wheel" in space . . . about 500 miles above the earth's surface (FR: ferry rocket).

The supply base for the "city in space": three-stage rockets with a launching weight of 10,390 short tons (for a payload of 35 tons each). Each stage is equipped with wings, tail and control system (for landing after completed mission), and the two lower stages also have dozens of jet engines.



3. Moon

Despite its popularity with the public, the moon was the subject of only four of the 44 Rome papers. *R. W. Buchheim* (Rand Corporation, Santa Monica) examined the possibility of circling the moon with an artificial satellite which would be visible from the earth. He came to the conclusion that such a moon's moon would have to have a weight of approximately 500 lbs. and would thus need a multi-stage transport rocket weighing some 450 tons. In addition extremely close tolerances for departure speed ($\pm$ 15 ft./sec) and departure angle ($\pm$ 0.3°) would have to be observed. *A. Boni* (Italy) proposed that relatively simple unmanned "moon messengers" armed with television cameras should be sent out, which "would not cost much more than the American I.G.Y. satellites". Finally the Americans *N. V. Peterson* spoke on the minimum size of manned moonships, and *K. R. Stehling* on small lunar rockets.

4. And all the stars . . .

Dr. Ing. E. Sänger (Research Institute for the Physics of Jet Propulsion), the promoter of the photon power plant[1], seriously discussed, in the confident expectation of further rapid progress in atomic physics and on the basis of Einstein's Special Theory of Relativity and

[1] cf. *Interavia* No. 11, 1953, p. 642.

its "time dilatation", the possibility of exploring the whole Milky Way. He came to the following interesting conclusions:

"We assume the limit case of a rocket vehicle with complete radiation of mass, in which the propellant masses carried aboard the vehicle are transformed entirely into photons or neutrinos, anti-neutrinos, gravitons etc. and are thus radiated in a pre-selected direction at the speed of light . . . (also) an acceleration equal to the earth's normal acceleration (9.81 m/sec) over all imaginable astronomic distances . . ."

(In view of the dilatation of time) ". . . the length of a human life would . . . be sufficient to travel round a whole static universe (approx. 3,000,000,000 light years). Whether our own solar system would still be in existence on the crew's return is more than doubtful, since more than 3,000,000,000 earth years would have passed . . .

"It is definitely not true that journeys to the fixed stars would take so many years that several generations would be born, grow up and die . . . The infinite universe is small enough to be open to each one of us personally right to its farthest limits; everything is accessible to man."

5. Space medicine and space law

Back to earth . . . with the papers by the aviation and space travel physiologist *Dr. phil. S. J. Gerathewohl* (School of Aviation Medicine, Randolph AFB) and the biologist *Major (U.S.A.F.) D. G. Simons* (Aero Medical Field Laboratory, Holloman Air Development Center).

Dr. Gerathewohl reported on the personal experience of 16 volunteers during brief periods of weightlessness in shallow dives or parabolic, upward curving flight paths. The test persons were carried in the second seat of a Lockheed T-33 jet trainer (in which weightlessness was achieved for periods of 10 to 30 seconds) or in a two-seat Lockheed F-94 all-weather fighter (weightlessness for up to 47 seconds). Their impressions of free hovering in space were very varied: Most of the men found the state of weightlessness comfortable; a number of persons reported sensations of motion such as falling, hovering and turning. A small group experienced discomfort and showed the characteristic symptoms of air and sea sickness. There appear to be considerable differences between individuals as regards both tolerance and adaptability. If suitable persons are chosen, the introduction of a permanent acceleration or "quasi-gravity" in spaceships will not be necessary.

Major Simons spoke on the biological effects of primary cosmic radiation, one of the most greatly feared dangers of space travel. To investigate these effects, the U.S. Air Force sent some 25 balloons carrying test animals—

Dr. H. Strughold and Dr. S. J. Gerathewohl (both of the U.S. Air Force's School of Aviation Medicine) in front of one of the Lockheed T-33 jet trainers at Randolph AFB, in which pilots achieved a state of weightlessness for periods of 30 seconds.

mice, guinea pigs, monkeys—up into the stratosphere, reaching heights of more than 20 miles and "exposure times" of up to 30 hours. One monkey, still alive, even spent 63 hours at altitudes above 115,000 ft. The animals were, of course, placed in heat-insulated pressure containers (of fibreglass). They kept warm by animal heat and were supplied with oxygen while the carbon dioxide was absorbed; air humidity 80%. — A particular sign of primary radiation was the graying of the hair in black mice, which occurred to a much greater extent than had been expected. Nevertheless Simons concluded that there would be no danger of serious damage to humans through primary cosmic radiation during exposures of less than 24 hours. Studies of longevity and further progress in cancer research might, however, change this result.

These two reports were followed by the Congress's final paper, read by the well-known aviation medical expert *Prof. T. Lomonaco* (Centro di Studi e Ricerche di Medicina Aeronautica, Rome) on physiopathological effects in space travel.

While the biologists and medicos could produce some concrete results of their researches, the space travel jurists are still empty-handed. With Accursius' legal principle, which still applies to aviation, "Cuius est solum, eius est usque ad coelum"[2], every space travel project could be throttled at birth. Fortunately President Eisenhower has declared the American I.G.Y. satellites, which will cross all countries between latitudes 40° north and 40° south, to be a purely civil project, so that no serious objections to the programme have so far been raised. What the various governments will say, however, when the first manned satellite vehicle is ready to take off may be another question.

In the face of this situation, the two legal experts who spoke in Rome, *A. A. Cocca* (Argentina) and *A. G. Haley* (United States) merely argued that something must soon be done to reach international agreement. The jurists should not allow themselves to be outrun by the engineers. A. A. Cocca combined this appeal with the—interesting—demand that Einstein's Special Theory of Relativity should also be applied to law: "Why should not law too be studied in the fourth dimension, since it applies to man, who is a four-dimensional being?"

*

One aspect of the Rome Congress that was particularly pleasant was the external setting. It must be admitted that, however enthusiastic the space travellers may get in theory about moon landscapes or planets with ammonia atmosphere, in practice they never fail to hold their meetings in pleasanter parts of the universe: Zurich in 1953, Innsbruck in 1954, Copenhagen in 1955, Rome in 1956.

The Congress was opened by Professor G. A. Crocco, President of the host "Associazione Italiana Razzi". His speech was followed by addresses by Senator Tupini, Mayor of Rome, and Frederick C. Durant, officiating President of the International Astronautical Federation. Altogether 23 space travel and rocket research associations from 22 countries[3] were represented, with a total of approaching 350 persons including guests.

Among the many well-known personalities in the audience there were Professors Ackeret (Zurich), Ambrosini (Rome), Broglio (Rome), Brun (Paris), Casiraghi (Genoa), Eula (Rome), Eugster (Berne), Gabrielli (Turin), Kaplan (Los Angeles), von Karman (Paris), Pirquet (Vienna), Sedov (Moscow), Zarankiewicz (Warsaw), Generals Alippi (Italy), Bergeron (France), Bruno (Italy), Davis and Flickinger (U.S.A.), Mancinelli, Pezzi and Raffaelli (Italy); engineers Cleaver (London), Gatland (Kingston-on-Thames), Gerber (Zurich), Müller (Buffalo, N.Y.), Shepherd (Chilton, Berks.), P. A. Smith (Washington, D.C.), Staats (Bremen), Steinhoff (Holloman AFB). This list naturally makes no claim to be complete.

On the final day of the Congress a new I.A.F. Committee was elected: Dr. L. R. Shepherd (United Kingdom) becomes Chairman; the four Vice-Chairmen are General P. J. Bergeron (France), F. C. Durant (United States), A. Sedov (U.S.S.R.) and T. Tabanera (Argentina). The I.A.F. Congress is to be held in Barcelona from October 7th to 12th, 1957.

Special highlights of the Rome Astronautical Congress were the reception of delegates and guests by Pope Pius XII at Castel Gandolfo (see "The Church and Space Travel") and the humorous speech by Professor Crocco at the farewell banquet in Palazzo Barberini. Alluding to Einstein's theory of time dilatation near the speed of light, he concluded: "It was a pleasure for me to meet you all yesterday in Copenhagen and to see you here today in Rome . . . Good-bye, *until tomorrow in Barcelona*."

[2] "The possession of land implies possession of the space above it, to the very Heavens themselves"; cf. *Interavia* No. 4, 1954, p. 238.

[3] Argentina, Austria, Belgium, Brazil, Canada, Chile, Czechoslovakia, Denmark, Egypt, Eire, France, Israel, Italy, Poland, Spain, Sweden, Switzerland, U.K., U.S.A., U.S.S.R., West Germany, Yugoslavia.

Can Man Reach Distant Celestial Bodies?

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Foreword : The majority of the following remarks were written several years ago, but remained filed away as the prospects of achieving very high speeds (comparable with that of light) seemed to me to be altogether too vague.

Meanwhile, however, similar studies, some of them going even further, have been published elsewhere [1], and interest in the no longer so new "paradoxes" of the special theory of relativity has grown. As the path followed here avoids the introduction of new concepts, readers may welcome its exposition, even if it brings nothing basically novel to light. — The problem of producing the high exhaust speeds will be discussed briefly at the end of the article and should therefore not cause too much concern at the start.

It is a favourite mental exercise among popular writers to endow space travellers with the speed of light and then resignedly comment that a human life is long enough to reach only the very nearest fixed stars [2], but that more distant objects will remain permanently out of our reach.

This conclusion is theoretically incorrect insofar as, under the (special) theory of relativity, even the greatest finite distances shrink for an observer in a space vehicle travelling near the speed of light, so that even distant nebulae can be "visited" in principle during a normal human life.

[1] E. Sänger: "Zur Theorie der Photonraketen", Ingenieur-Archiv, Berlin 1953, Vol. XXI, pp. 213-226.

[2] Listed in *Russel*; *Dugan, Stewart*, Astronomy Vol. II, p. 632, Boston 1927.

True, the vehicle would have a speed *very close* to that of light, which would require high accelerations; these would pose physiological problems, quite apart from the tremendous energy involved. It will thus be necessary to examine these conditions with particular care.

*

In order to avoid unnecessary complications, we have simplified the problem as follows : the space vehicle would start from a fixed base (earth) and move in a straight line towards its distant target, whose speed relative to the earth is ignored. Braking would then begin at mid-trajectory and continue until zero speed is reached again, at the target. During the return journey everything would take place in the opposite order.

A careful definition must obviously be made of the systems of coordinates and the clocks on which lengths and times are based. Distance measured from the earth will be given here as x, and time by an earth clock as t. For the space traveller distances measured from the space vehicle are x' and time by a clock of the same make t'.

At the beginning of the journey both clocks —on the ground and in the vehicle—show the same time ($t = t' = 0$). In ordinary mechanics t always remains equal to t'; in relativity mechanics, however, the position is different.

The speed of the spaceship (in the earth system) is given as v. It increases constantly from zero to a maximum value very close to the speed of light c.

Forces of gravity can be ignored. For those who dream of the speed of light such forces are mere bagatelles, and in fact the field of gravity rapidly falls to minute quantities as distance increases. Speed v is also considered to vary *slowly*, so that accelerations b are not so great that the vehicle's occupants would not survive them.

*

Changes in distance and time, as observed on the one hand by an observer on earth and on the other by the space traveller, can be compared by means of the *Lorentz transformation* (*equations 1 and 2*; formulae on following page — Ed.)

If we introduce speeds u and u' (equations *3a* and *3b*)—namely for a particle which can move even in relation to the rocket — equation *2* becomes *4*, and the relativistic addition theorem gives equation *5* and hence *6*.

The two latter equations enable acceleration (in the earth-bound system) to be calculated, with speed v at present being considered as constant. This gives an expression as in equation *7a*, which can also be written in the simpler form *7b*.

Processes on board the spaceship must also be examined more closely. Though the space traveller (mass point m) does not accelerate in relation to his vehicle, he should be under the influence of an apparent gravity mb. This means that the spaceship itself must accelerate in such a way that the inertial effect of mass m becomes exactly equal to mb.

We can thus write $(\dot{u})' = b$ and ignore u' in equation *5* and in the denominator of equation *7b*, so that $\dot{u} = \dot{v}$, and equation *7b* is transformed into *8a*. The latter can also be written in the form of *8b* and after integration (with $v = 0$ at $t = 0$) gives *9a*. If *9a* is resolved over v/c we get *9b*, which shows that even over a very long period of time the vehicle speed cannot exceed the speed of light.

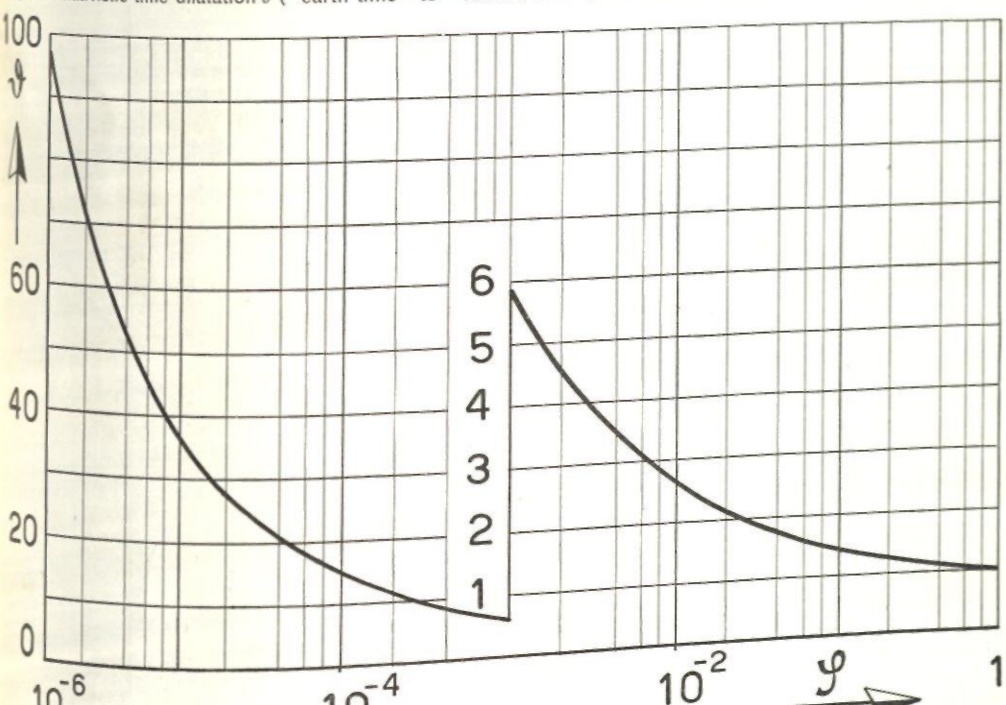
Seen from the earth, the rocket accelerates at a decreasing rate and takes a very long time to approach the speed of light.

*

Turning now to the space vehicle's system of coordinates, equation *6* becomes *6a* for $u' = 0$, and equation *8b* is replaced by *10*. If the latter is integrated it gives equation *11* or — resolved over v/c — equation *12*.

Equation 12 reveals that the ratio of the vehicle's speed (measured from the earth) to the speed of light (sometimes known as Einstein's number) is equal to the hyperbolic tangent to the quotient of the speed as measured aboard the vehicle (acceleration times vehicle time) and the speed of light. *Thus a different relationship from that in equation 9b appears.*

Fig. 1 : Relativistic time dilatation θ ("earth time" to "vehicle time") for various speed conditions $\varphi = 1 - v/c$.



$$(1)\quad dx' = \frac{dx - v\,dt}{\sqrt{1 - v^2/c^2}}$$

$$(2)\quad dt' = \frac{dt - \frac{v}{c^2}dx}{\sqrt{1 - v^2/c^2}}$$

$$(3a)\quad \frac{dx}{dt} = \dot{x} = u$$

$$(3b)\quad \frac{dx'}{dt'} = (\dot{x})' = u'$$

$$(4)\quad \frac{dt'}{dt} = \frac{1 - \frac{v}{c^2}\frac{dx}{dt}}{\sqrt{1 - v^2/c^2}} = \frac{1 - \frac{vu}{c^2}}{\sqrt{1 - v^2/c^2}}$$

$$(5)\quad u = \frac{u' + v}{1 + \frac{vu'}{c^2}}$$

$$(6)\quad \frac{dt'}{dt} = \frac{1 - \frac{v}{c^2}\frac{u'+v}{1+vu'/c^2}}{\sqrt{1 - v^2/c^2}} = \frac{\sqrt{1 - v^2/c^2}}{1 + vu'/c^2}$$

$$(7a)\quad \dot{u} = \frac{du}{dt} = \frac{(1+\frac{vu'}{c^2})\frac{du'}{dt'}\frac{dt'}{dt} - (u'+v)\frac{v}{c^2}\frac{du'}{dt'}\frac{dt'}{dt}}{(1+\frac{vu'}{c^2})^2}$$

$$(7b)\quad \dot{u} = (\dot{u})'\frac{(1 - v^2/c^2)^{3/2}}{(1 + vu'/c^2)^3}$$

$$(8a)\quad \dot{v} = b(1 - v^2/c^2)^{3/2}$$

$$(8b)\quad b\,dt = \frac{dv}{(1 - v^2/c^2)^{3/2}}$$

$$(9a)\quad \frac{bt}{c} = \frac{v/c}{\sqrt{1 - v^2/c^2}}$$

$$(9b)\quad v/c = \frac{bt/c}{\sqrt{1 + (bt/c)^2}}$$

$$(6a)\quad \frac{dt'}{dt} = \sqrt{1 - v^2/c^2}$$

$$(10)\quad b\,dt' = \frac{dv}{1 - v^2/c^2}$$

$$(11)\quad \frac{bt'}{c} = \frac{1}{2}\ln\frac{1 + v/c}{1 - v/c}$$

$$(12)\quad v/c = tgh\left(\frac{bt'}{c}\right)$$

$$(13)\quad \vartheta = \frac{2v/c}{\sqrt{1 - v^2/c^2}\,\ln\frac{1+v/c}{1-v/c}}$$

$$(1a)\quad dx = \frac{dx' + v\,dt'}{\sqrt{1 - v^2/c^2}}$$

$$(1b)\quad dx = \frac{v\,dv}{b(1 - v^2/c^2)^{3/2}}$$

$$(14)\quad x = \frac{c^2}{b}\left\{\frac{1}{\sqrt{1 - v^2/c^2}} - 1\right\}$$

$$(15)\quad x = \frac{c^2}{b}\left\{\cosh\frac{bt'}{c} - 1\right\}$$

$$(16)\quad x = \frac{c^2}{b}\left\{\sqrt{1 + \left(\frac{bt}{c}\right)^2} - 1\right\}$$

$$(16a)\quad \left(x + \frac{c^2}{b}\right)^2 - c^2t^2 = \frac{c^4}{b^2}$$

$$(15a)\quad \xi = \left(\frac{c}{\beta g S}\right)\left\{\cosh\frac{\beta g S \tau'}{c} - 1\right\}$$

$$(17)\quad \xi \cong \frac{1}{\beta}\left\{\cosh \beta\tau' - 1\right\}$$

$$(12a)\quad \varphi = 1 - v/c = 1 - tgh\,\beta\tau'$$

$$(18)\quad \mu_1 = \left(\frac{1 - (v/c)_{max}}{1 + (v/c)_{max}}\right)^{1/2}$$

$$(19)\quad \mu_{tot} = \mu_1^4 = \left(\frac{1 - (v/c)_{max}}{1 + (v/c)_{max}}\right)^2$$

$$(20)\quad \mu_{tot} = \mu_1^2 = \frac{1 - (v/c)_{max}}{1 + (v/c)_{max}}$$

If now Einstein's time dilatation t/t' is written as θ, we get equation *13* — independent of b — and can plot time dilatation against v/c or $1 - v/c = \varphi$ in the form of a curve (cf. *fig. 1*). *This curve reveals that no perceptible effects of relativistic time dilatation can be expected until the speed of light is approached very closely.*

*

To ascertain the distance covered, we start from the inverse formula to *equation 1*, in the form shown in *1a*. Assuming $dx' = 0$ (no motion inside the rocket) the result, obtained with the aid of equation *10* (for dt') is equation *1b*. Integration (with $x = 0$ for $v = 0$) gives equation *14*, from which *15* can be derived with the aid of *12*. Here it should be noted that equation *15* turns into the classic value $x = 1/2\, b\, (t')^2$ at the beginning of the motion.

Equations *14* and *9b* give *16*, which can also be written as in *16a*. Converted into a distance-time diagram, *16a* gives a hyperbola. We have here *Born's hyperbolic motion.*

*

Let us now introduce other terms. Acceleration b is taken as equal to βg, where g is the earth's gravity acceleration (981 cm/sec^2), times are expressed as relative to the number of seconds per calendar year ($S = 3.15 \times 10^7$ sec) and distances measured as fractions of light years (1 light year $= c \cdot S = 9.45 \times 10^{17}$ cm).

Under these conditions we can write " earth time " as $\tau = t/S$ and the corresponding " vehicle time " as $\tau' = t'/S$. Also, distance in light years becomes $\xi = x/cS$, so that *equation 15* can be expressed as *equation 15a*. If we then substitute the figure values for g, c and S, we get *approximately the simple formula shown in equation 17.*

This function is shown in graph form in *fig. 2* for four values of β. This diagram thus shows the distance covered in light years during the acceleration period (with 1g, 1.5g, 2g and 3g) as a function of " vehicle time ".

In the same way equation *12* can be converted into *12a*, whose evaluation (for the same four values of β) is shown in *fig. 3*.

On the subject of *figs. 2* and *3* it should be noted that four times the vehicle time τ' is required for a complete round trip and that the distance of the destination planet from the earth is equal to $2\,\xi$.

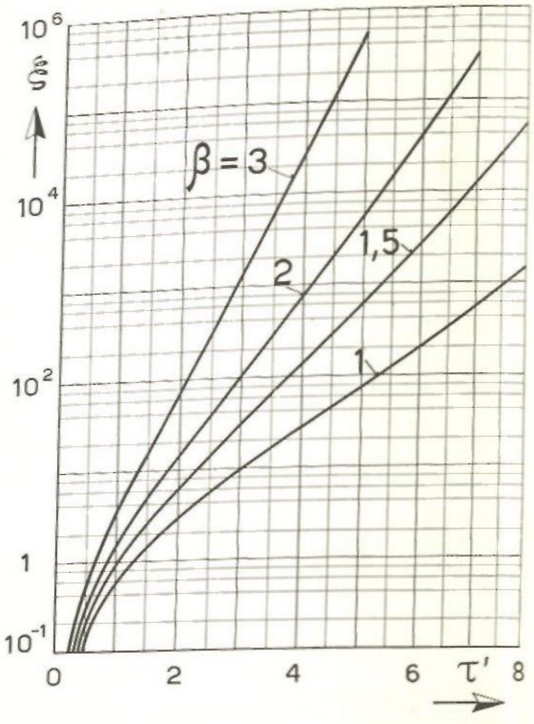


Fig. 2 : Distance covered in light years ξ during one period of acceleration. Vehicle time τ' (for an observer in the vehicle) is given in years ; the parameter is acceleration βg.

Let us assume, for example, that τ' is exactly two years, in other words that the space traveller's whole trip (without staying at his destination) would take eight years. Let us also assume that acceleration factor β is equal to one, so that space travellers perceive no difference compared with weight conditions on earth. In this case they would not be in a state of weightlessness—an advantage, since it is not yet known whether man can tolerate this state for long without damage.

According to *fig. 2* and *equation 15*, ξ is equal to 2.76 light years, the distance of the destination from the earth thus 5.52 light years or 5.21×10^{18} cm, which corresponds roughly to the distance to *Proxima Centauri*, the very nearest fixed star 4.3 light years away. *Equation 12* gives the ratio of maximum vehicle speed to the speed of light as $v/c = tgh\ 2 = 0.964$, and *equation 13* factor θ as 1.81.

Fig. 3 : Space vehicle speeds $\varphi = 1 - v/c$ plotted against " vehicle time " τ' for various accelerations βg.

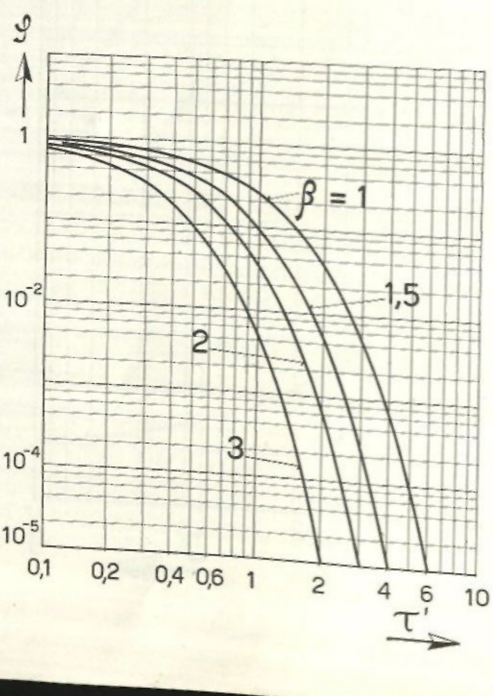
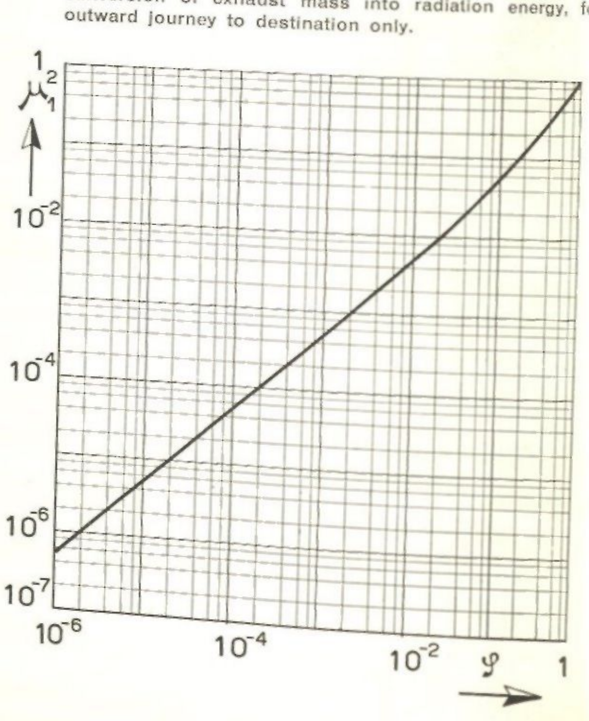


Fig. 4 : Mass ratio required for a photon rocket with full conversion of exhaust mass into radiation energy, for outward journey to destination only.



In other words, in this case the vehicle's maximum speed as measured on earth would seem to be 96.4% of the speed of light and the round trip would take 1.81 × 8 = 14.5 earth years.

So the space travellers would age by only eight years during the journey, there would be a "time gain" of 6.5 years. On return to earth the travellers would appear 6½ years younger than their contemporaries.

For a journey with higher acceleration or deceleration, e.g., for $\beta = 2$, which would perhaps still be just feasible physiologically (provided the vehicle's occupants remained otherwise motionless), the distance covered and the relativistic "rejuvenation" would be greater: $2\xi = 26.31$ light years; $(v/c)_{max} = 0.9999$, $(\varphi = 0.0007)$: $\theta = 6.74$. — On earth 53.9 years would have passed, so that the travellers would have gained 45.9 years ... and would thus be biologically "younger" than the children they had left at home.

•

Meanwhile, however, it must be remembered that it requires an enormous consumption of energy in order to approach close to the speed of light. If such extreme speeds are to be attained, reaction must be by *light particles* (photons), i.e., a photon rocket (Sänger) must be used. Also it must be remembered that practically the whole propellant mass would have to be transformed into energy and that even so this propellant mass would make up almost the whole mass of the space vehicle. *Today we have just reached the stage, even in nuclear reactions, where roughly one thousandth of the "rest" mass is transformed into energy.*

Admittedly, so long as we are ignorant of the reasons for the stability of protons, it would be premature to maintain that a greater transformation of mass into energy is impossible in principle. If this is assumed as possible, the calculation of mass ratios must be based on the relativistic rocket equation for photons.[3]

The ratio of the mass at the end of the acceleration period to the initial mass can be designated μ_1 and calculated from *equation 18.* For the round trip (with two acceleration and two deceleration periods) $\mu_{tot} = \mu_1^4$ therefore applies *(equation 19)*.

A simple calculation, based for example on the figures for a journey to Proxima Centauri, produces *extreme mass ratios*: a tremendous mass would have to be provided on departure and to be almost entirely radiated, in order to bring a very small mass (crew, cabin, propulsion mechanism) back to earth on completion of the trip. Only if the propellant radiated could be replaced at the destination, or if no return to earth is planned, would the mass ratio become more favourable, as in this case it would be calculated from *equation 20.*

[3] Cf. *J. Ackeret:* Helvetiae physica acta, Vol. 19 (1946), p. 106.

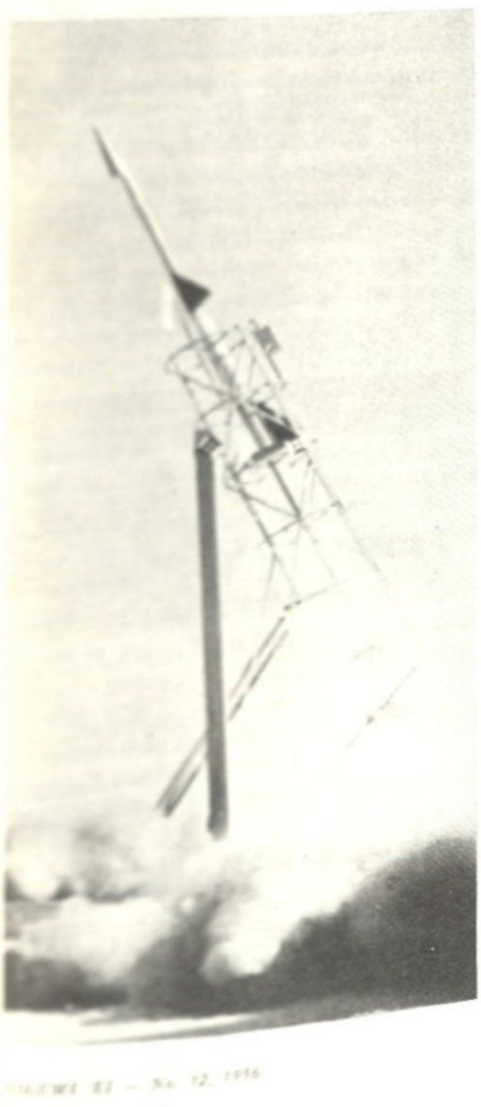
The last equation (*20*) is presented in graph form in *fig. 4.* For example, for $(v/c)_{max} = 0.999$; i.e., for $\varphi = 10^{-3}$, a mass ratio of 1 : 2,000 would be needed. As the ultimate mass of the space vehicle could scarcely be less than 50 tons—since the space travellers would have to be housed, fed, ventilated, lit and heated for at least eight years — the departure mass would have to be at the very least 100,000 tons, and probably considerably more. — *It is thus clear that, even with daring assumptions, there can be no question of space journeys to beyond the nearest fixed stars.*

•

A journey of this kind would have no sense unless it could be hoped to find and explore foreign planetary systems. Here perhaps forms of life very different from our own might be discovered, so that biology might gain.

It must, however, be asked whether there is not infinitely more to be gained from terrestrial research, which after all is only on the threshold of the exploration of life. From the astrophysical point of view the result would probably be small, as 99% of matter is in a gaseous form. An astronomical observation post on the moon will suffice to do everything that can be expected in this domain. Thus the old saying still retains its force:

If thou the infinite wouldst bestride,
Know first the finite on every side.



American Two-Stage Rockets

A few weeks ago first details were released of two new types of American research rockets which bear the designations **Hypersonic Test Vehicle** and **Terrapin**. Both are two-stage rockets for solid propellant.

The **Hypersonic Test Vehicle** (left), as the name indicates, is a supersonic vehicle for very high Mach numbers and has been developed over the past three years by Aerophysics Development Corporation (subsidiary of the Curtiss-Wright Corporation) in conjunction with the Wright Air Development Center, Air Research and Development Command. A first test firing was made in November 1954. Meanwhile another 14 rockets have been launched, most of them from mobile launchers at N.A.C.A.'s Wallops Island, Virginia, proving ground. The last rockets in the experimental series reached final-stage speeds equivalent to **Mach 10.5** and climbed "several hundred miles" into the atmosphere.—The first stage has a calibre of 9 inches, a length of 5 ft. and is powered by seven parallel solid-propellant combustion chambers burning simultaneously. After burnout of the first stage the second stage is automatically ignited. It also measures 5 ft. in length, but has a calibre of 6 inches and carries only four combustion chambers. The nose cone of the second stage carries measuring instruments and a magnetic tape recorder. On reaching the maximum altitude, the second stage's four fins are automatically blown off, so that the burnt-out rocket falls to earth in a flat spin at about 100 m.p.h.

The **Terrapin** (right) is a joint development by Republic Aviation Corporation and the University of Maryland (cf. November issue, p. 898), for which Allegheny Ballistics Laboratory and Thiokol Corporation supplied the propellants. The **Terrapin** has also been tested at Wallops Island: length 15 ft., diameter 6¼ ins., launching weight 224 lbs., burnout speed of second stage equivalent to Mach 5.8, peak altitude 80 miles.